Large intrinsic anomalous Hall effect arising from antiferromagnetism in NbMnP

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The anomalous Hall effect (AHE), typically observed in ferromagnets, has been discovered in some antiferromagnetic (AF) materilas such as Mn_3Sn [1]. When the AF structure is represented by the magnetic point group allowing ferromagnetism, the AHE can appear as a macroscopic phenomenon. In the intrinsic mechamisn of AHE, an electric-field induces transverse anomalous velocity, which is dissipationless. In this case, the anomalous Hall conductivity (AHC) can be calculated from a band structure of each material, and is independent of scattering. Therefore, we can expect that the AHC is independent on longitudinal conductivity or crystal quality; however, absence of high-quality crystals in AF materials exhibiting a large AHE has prevented the experimental investigation of the origin of the AHE.

Recently, we discovered the large AHE in AF non-collinear magnet NbMnP [2]. The AF structure of NbMnP is represented by a combination of the magnetic point group mm'm' (irreducible representation B_{3g}) and mm'm (B_{2u}). The mm'm', which is represented by magnetic troidal quadrupole, induces the AHE even from the AF structure, because it symmetrically allows ferromagnetic components along the *a*-axis. Actually, the net magnetization as small as $10^{-3}\mu_B$/Mn emerges behind the AF structure. The observed AHC was σ_{AH} = 230 ohm^{-1}cm^{-1}, which was reproduced by the theoretical calculation. This supports the band-structure originating intrinsic nature of the AHE; however, the impurity-scattering dependence of σ_{AH} has not been verified even in NbMnP, because RRR (residual resistivity ratio) was 2 as well as other AF materials showing the AHE.

In this study, we obtained high-quality NbMnP crystals by changing the flux. The largest RRR of the new crystals exceeded 40 and an occupancy of Nb atoms got close to stoichiometric. We report high-quality NbMnP also shows large AHE and weak net magnetization, which are comparable to those in the previous crystal with low RRR. The results experimentally suggest that the AHE in NbMnP arises from the AF spin configuration through the intrinsic band-structure effect [3].

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